

DEMONSTRATION OF HORIZONTAL AND INTERSECTING RAINBOWS.<sup>1</sup>

By KŌKICHI OTOBE.

Read before the Tokyo Mathematico-Physical Society, Dec. 16, 1916.]

*Demonstration of horizontal rainbows.*

(1) The observation of horizontal rainbows has been described by several writers. I, also, was so fortunate as to observe the same phenomenon on the water surface of the castle moats near Kikyo-Mon and Babasaki-Mon. The rainbow observed occurred at about 11 a. m. November 22, 1916.

The surface of the water was covered with soot which was probably loaded with fine water drops. This suggested to me the following method for demonstrating the phenomena:

(2) A large glass plate (70 cm. × 70 cm.) is coated with lampblack, placed in a horizontal position on a table, and fine drops of water sprayed over the surface. Looking obliquely upon the plate when the latter is illuminated by the sun, the brilliant primary bow is seen, and even the secondary bow can readily be observed.

In general the branches of the curve are open, being hyperbolic or parabolic. The appearance and the extent of the bow depend on the height of the observer's eye above the plate. The lower the height the more curved will be the arc at its vertex. By holding the plate at a suitable inclination there is seen a nearly closed, elliptical arc about the shadow of the observer's head.

When the plate is held perpendicularly to the incident rays, however, it becomes semitransparent, unless the lampblack coating is sufficiently thick to prevent this, and one often fails to see the circular rainbow which is then masked by the direct and transmitted rays.

(3) The latter trouble is not experienced, even with the same (less heavily smoked) plate, if we work in a dark room with rays from an electric arc light, for then the background is much darker.

(4) General remarks: (a) A slate, or marble, or even wooden slab may be used in place of a glass plate, but the latter gives the best results. (b) In order to see the rainbow colors sharply defined it is necessary to work with the smoked plate immediately after spraying it with water. The spraying may be repeated several times as the drops vaporize and the rainbow becomes faint.

[To realize the actual mode of formation of the horizontal rainbow observed on the surface of the water the following method is recommended: Along the edges of a large glass plate, a water-tight rim is formed by successive applications with a small brush dipped in melted

paraffin wax. By pouring water into this shallow basin a brimming water surface may be obtained. Then sift soot upon the water surface from a fine cotton sieve and proceed as in the former case.]<sup>2</sup>

*Demonstration of intersecting bows.*

(5) The intersecting rainbows observed in nature are explained as due to direct rays of the sun and to reflected rays from its image in a large sheet of calm water lying behind the observer. Theoretically this explanation is evident, but so far as the author is aware its demonstration in a laboratory has never been tried.

The same method as that described above enabled me to show two distinctly intersecting bows in the laboratory.

In a dark room an arc light was used as the source of direct light, and an ordinary glass mirror (25 cm. × 17 cm.) as the reflector. The two light sources may be placed a few meters apart. Then the observer, standing at a point where the two lights are of nearly equal intensity, should close one eye and with the other regard a blackened plate held at a suitable inclination.

## AURORA OF AUGUST 26, 1916, OBSERVED AT HESSEL, MICH.

By FRANCIS E. NIPHER.

[Dated: Hessel, Mackinac County, Mich., Sept. 2, 1916.]

On the evening of August 26, 1916, we had here (lat. 46° 0' N., long. 84° 25' W.) a very remarkable auroral display. It began as an ordinary northern light appearance at about 8 p. m. Then a band of light appeared gradually, which reached from the east and west horizons across the zenith.

Then apparent discharges appeared all around the horizon, reaching gradually to a point a few degrees south of the zenith. They appeared like pulsating discharges. They took the form of clouds which were in continual pulsations toward the point of convergence.

They looked exactly like discharges in a tube with a partial vacuum, when put in contact with the terminals of an electric machine. We have often had here auroral displays in the north, the streamers diverging from the north and even crossing overhead and converging toward the south. I never before saw a display where everything seemed to converge toward a point overhead, and which looked like a discharge toward that point. \* \* \*

The lake level was at this time the lowest of the summer. No wind. Barometer therefore probably high.

<sup>1</sup> Reprinted from Proc., Tokyo math.-phys. soc. Jan., 1917, (2) 9:16-17.<sup>2</sup> This paragraph is quoted from the version of this summary published in Journal of the Meteorological Society of Japan, Feb. 1917, 36:1-6, illustrated by 2 photographs.